Nuclear Energy University Programs

FC3: Nuclear Materials Safeguarding and Instrumentation (aka: MPACT)

Daniel Vega
MPACT Federal Program Manager

August 10, 2011 Chicago, Illinois

Nuclear Materials Safeguarding and Instrumentation Overview

- Background of MPACT Program
- FY 2011 and 2012 elements
- 2012 NEUP Workscopes

NE's Four R&D Objectives:

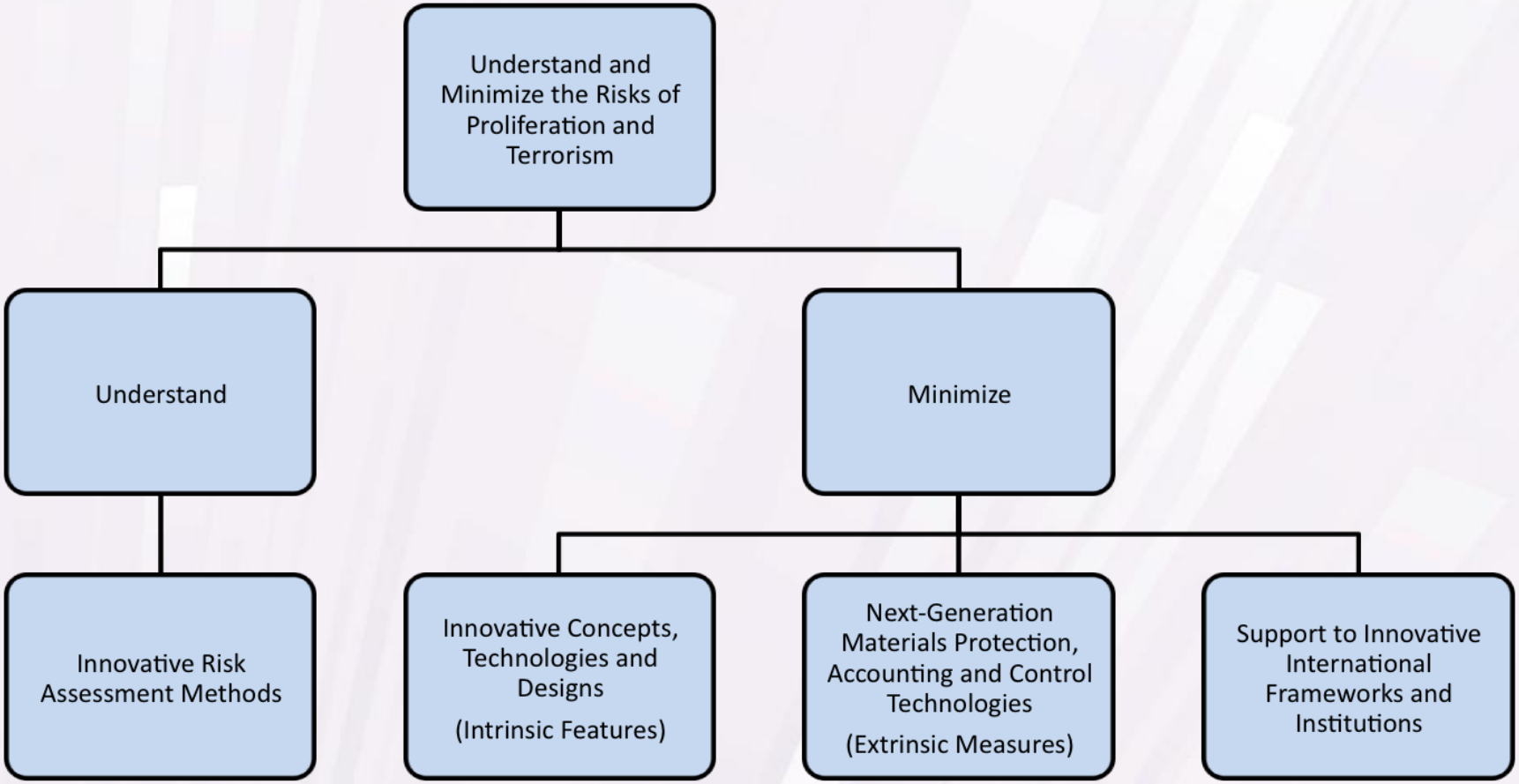
1. Develop Technologies and Other Solutions that Can Improve the Reliability, Sustain the Safety, and Extend the Life of ***Current Reactors***

2. Develop Improvements in the Affordability of ***New Reactors*** to Enable Nuclear Energy to Help Meet the Administration's Energy Security and Climate Change Goals

3. Develop Sustainable Nuclear ***Fuel Cycles***

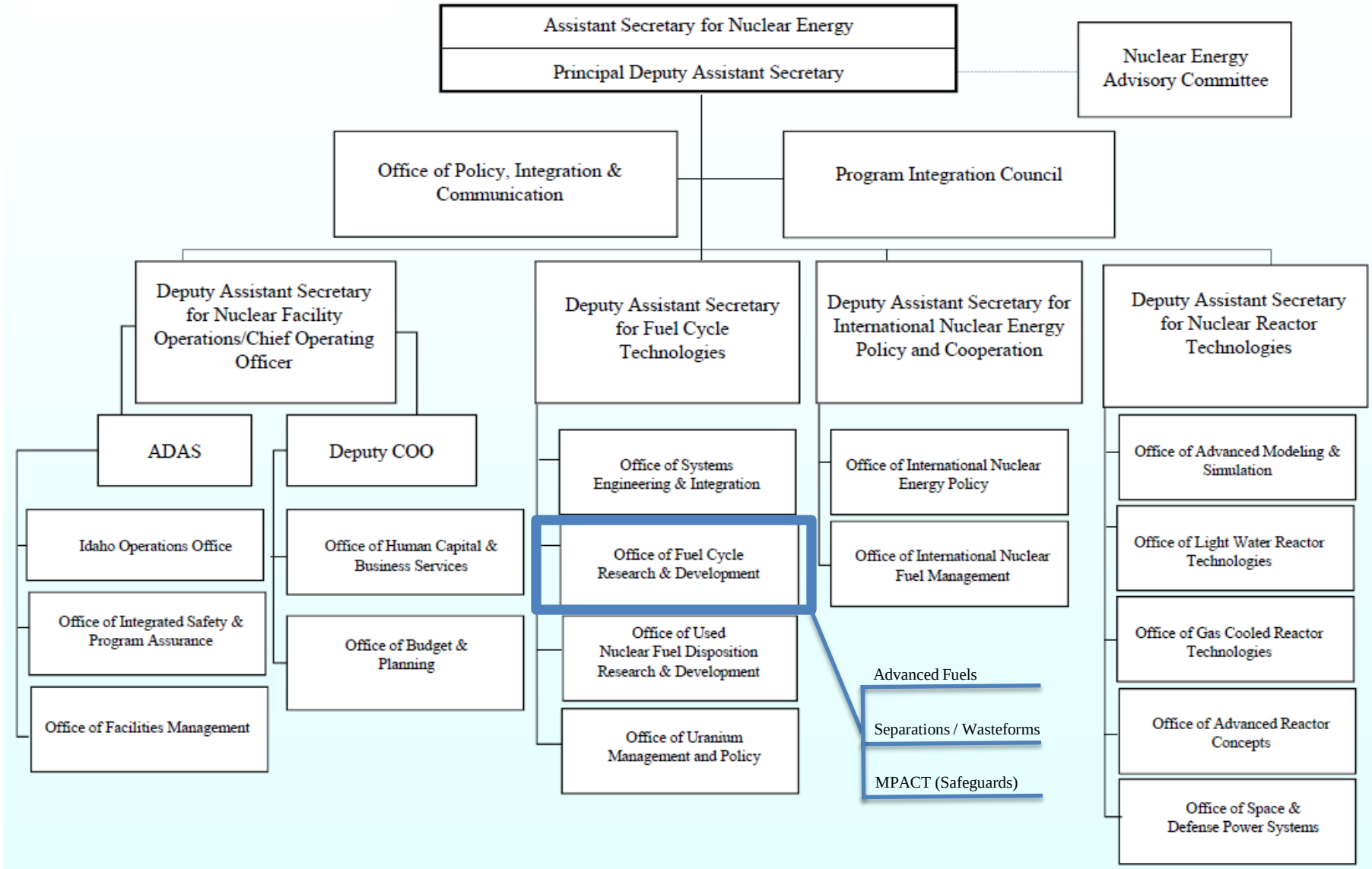
4. Understand and Minimize the Risks of Nuclear ***Proliferation and Terrorism***

R&D Objective 4



Safeguards and Security By Design

MC&A


Assistant Secretary for Nuclear Energy
Principal Deputy Assistant Secretary
Nuclear Energy Advisory Committee
Office of Policy, Integration & Communication
Program Integration Council
Deputy Assistant Secretary for Nuclear Facility Operations/Chief Operating Officer
Deputy Assistant Secretary for Fuel Cycle Technologies
Deputy Assistant Secretary for International Nuclear Energy Policy and Cooperation
Deputy Assistant Secretary for Nuclear Reactor Technologies
ADAS
Deputy COO
Idaho Operations Office
Office of Integrated Safety & Program Assurance
Office of Facilities Management
Office of Human Capital & Business Services
Office of Budget & Planning
Office of Systems Engineering & Integration
Office of Fuel Cycle Research & Development
Office of Used Nuclear Fuel Disposition Research & Development
Office of Uranium Management and Policy
Office of International Nuclear Energy Policy
Office of International Nuclear Fuel Management
Advanced Fuels
Separations / Wasteforms
MPACT (Safeguards)
Office of Advanced Modeling & Simulation
Office of Light Water Reactor Technologies
Office of Gas Cooled Reactor Technologies
Office of Advanced Reactor Concepts
Office of Space & Defense Power Systems

"Safeguards"

- Domestic: State level institutions' measures to enhance *nuclear security and accountancy*.
  - **Threats: Theft, Sabotage**

- International: IAEA or Regional Authority's measures to detect/prevent *proliferation* - state is considered the potential adversary
  - **Threats: Diversion, Misuse (neutron theft), Breakout**

- Safeguards is often (incorrectly) presumed to mean "International" or IAEA Safeguards

Nuclear Materials Safeguarding and Instrumentation Overview

Mission:

Develop innovative *technologies and analysis tools* to enable next-generation nuclear materials management for future U.S. nuclear energy systems

Challenges:

- Regulatory gaps exist in licensing approach for some potential U.S. back-end fuel cycle facilities (storage, disposition, and/or recycling)
- Limitations of accuracy and timeliness of detection (especially in high radiation fields)
- New reactor designs require new nuclear material management approaches (SMRs, Gas-Cooled Reactors, Thorium, etc.)
- Large throughput can present logistical MC&A challenges, and require shutdown for periodic inventory

Grand Challenge

- Develop online, real-time, continuous, accountability instruments and techniques that permit an order of magnitude improvement in the ability to inventory fissile materials in domestic fuel cycle systems, in order to prevent and detect theft, sabotage, or misuse.

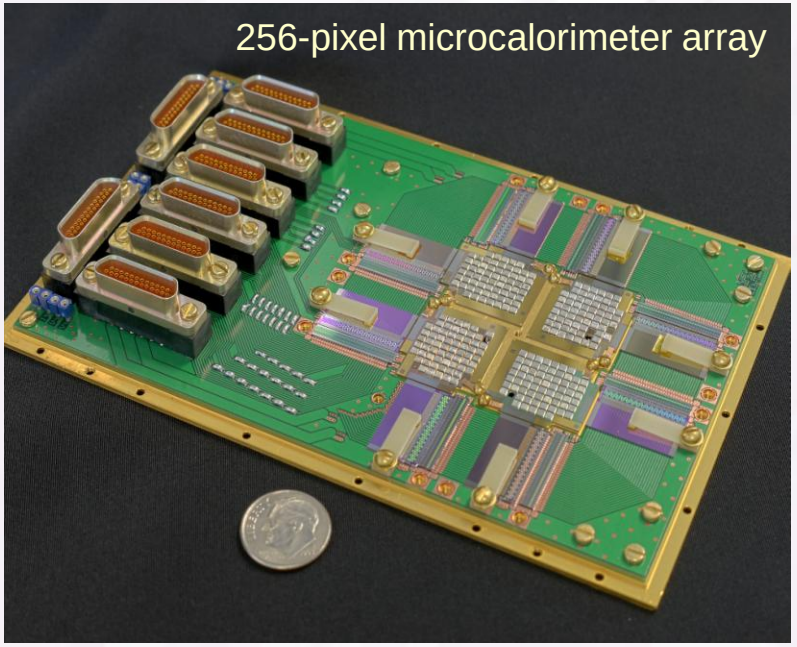
Nuclear Materials Safeguarding and Instrumentation Elements

- Advanced Instrumentation (mainly accounting and control technologies)
- Advanced Concepts and Integration (mainly analysis tools)
- Safeguards and Security by Design (“design it in up front, rather than retrofit later”)
- Modeling and simulation tools to support all of the above,

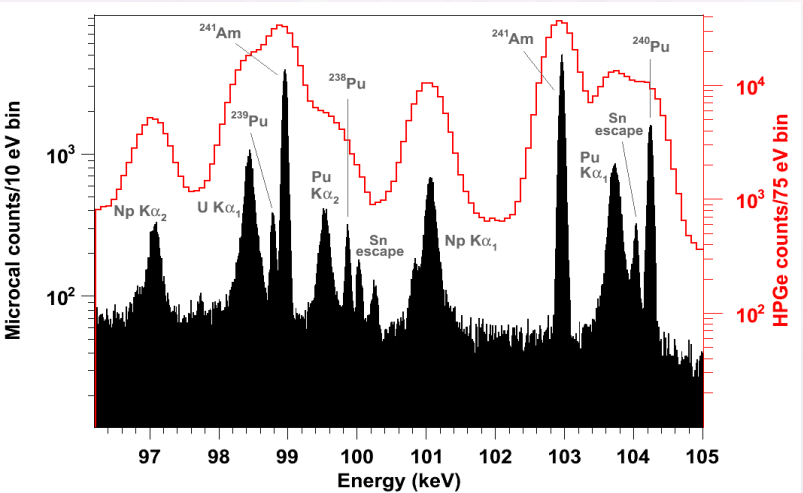
Microcalorimeter Array

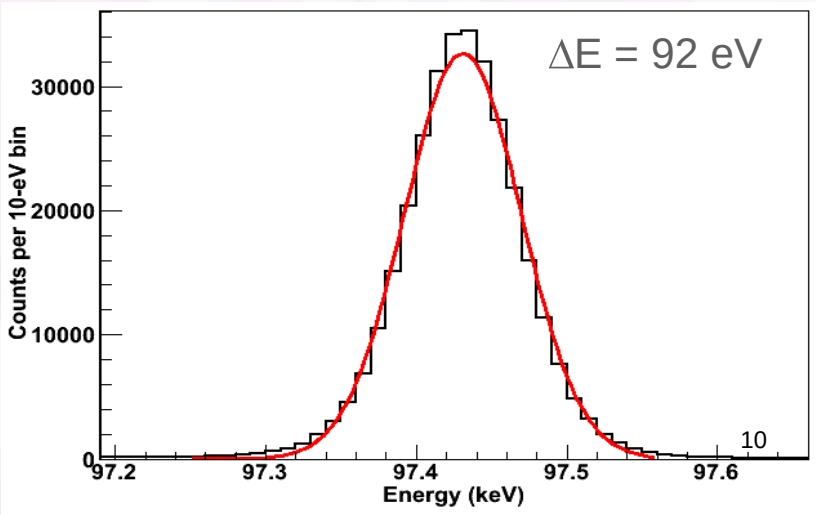
FY11 activity to date:

- 256-pixel array installed at LANL (fabricated at NIST-Boulder)
- New reliability tests to establish TRLs
- 169 pixels (66%) producing data from ^{153}Gd check source; 92 eV FWHM at 97 keV
- 128-pixel simultaneous multiplex operation
- Failure modes for most remaining pixels understood and can be addressed in next array fabrication



Microcal and HPGe plutonium source data from previous (smaller) 2009 detector array

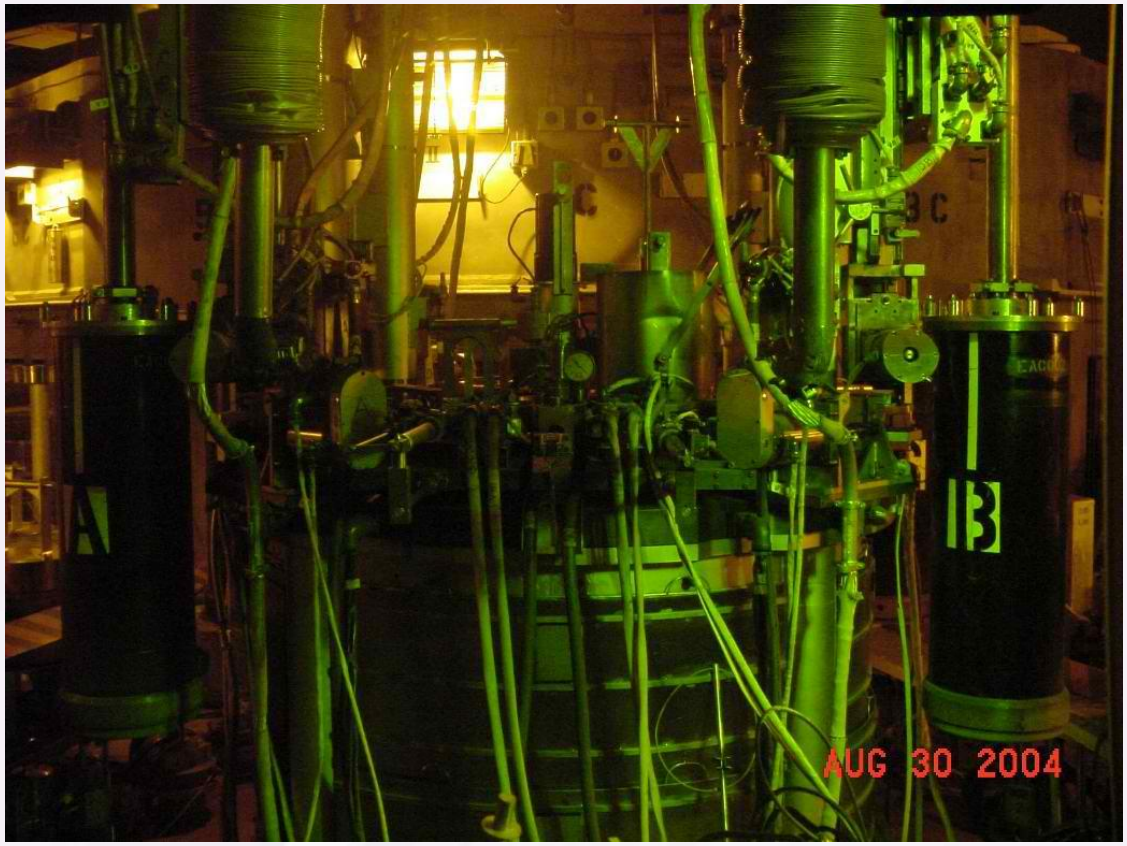




Electrochemical Sensor for Actinides in Molten Salt

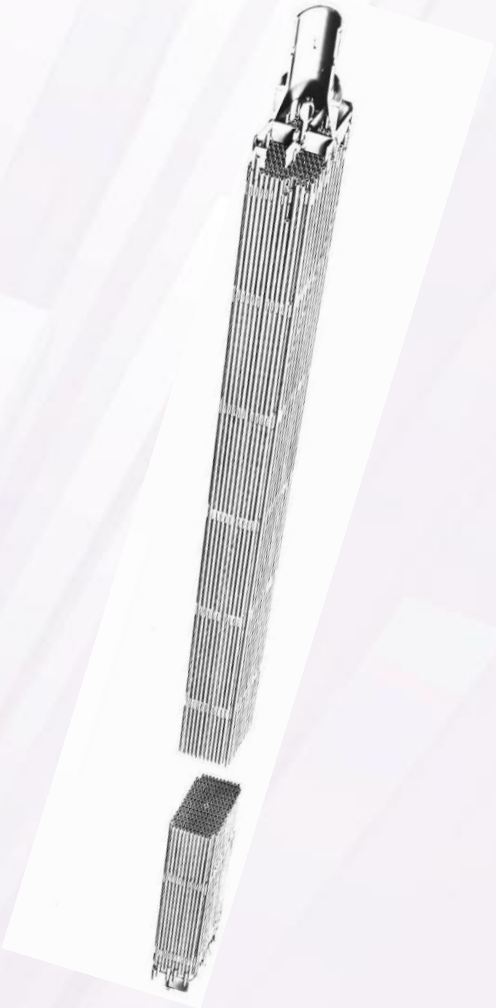
<u>FY11 activities to date:</u>

- Design
- Mechanical testing
- Sensitivity analyses for process monitoring applications



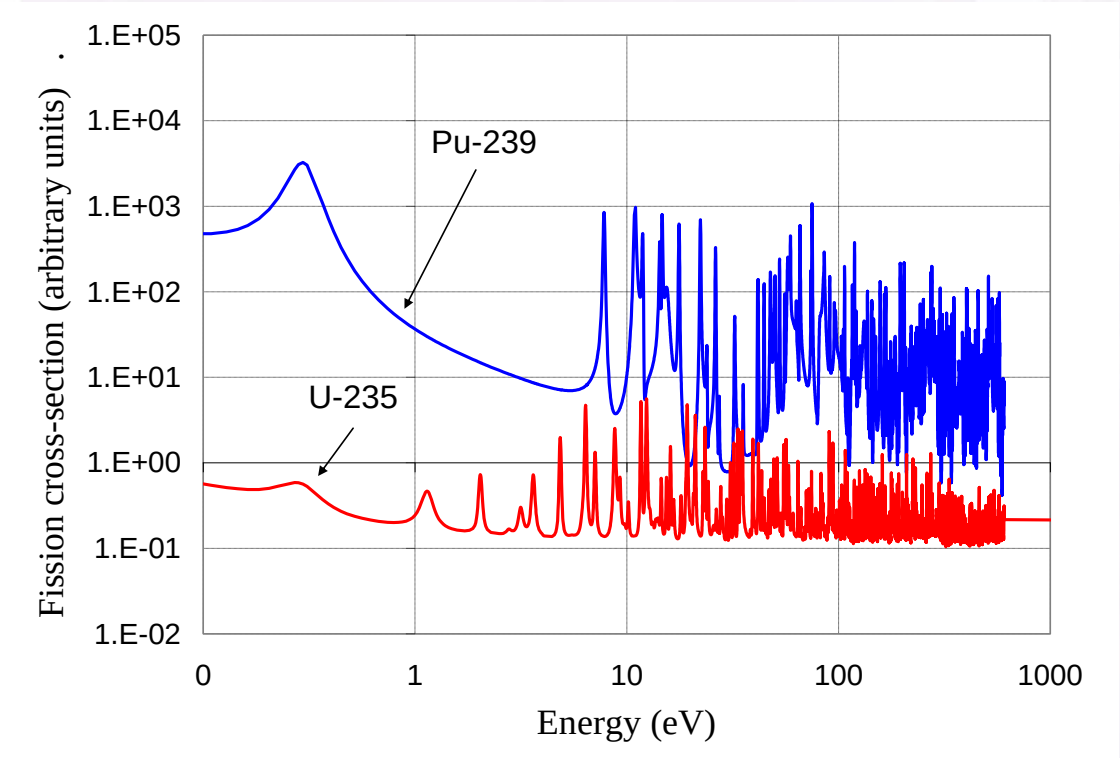
Direct Measurement of Pu in Used Fuel

- Current NDA methods: Infer Pu isotopic mass
  - Burnup calculations + “Easy” signatures (e.g. Cs-137, Cm)
  - Pu uncertainty ~10%
- Ideal NDA: Direct measurement of Pu
  - Independent (no operator-declared information)
  - Pu uncertainty <1% → partial defect detection
  - Timely, cost-effective, operationally tolerable
- Potential MC&A applications
  - Spent fuel storage (e.g. shipper-receiver)
  - Head-end of recycling facilities
  - Burnup credit

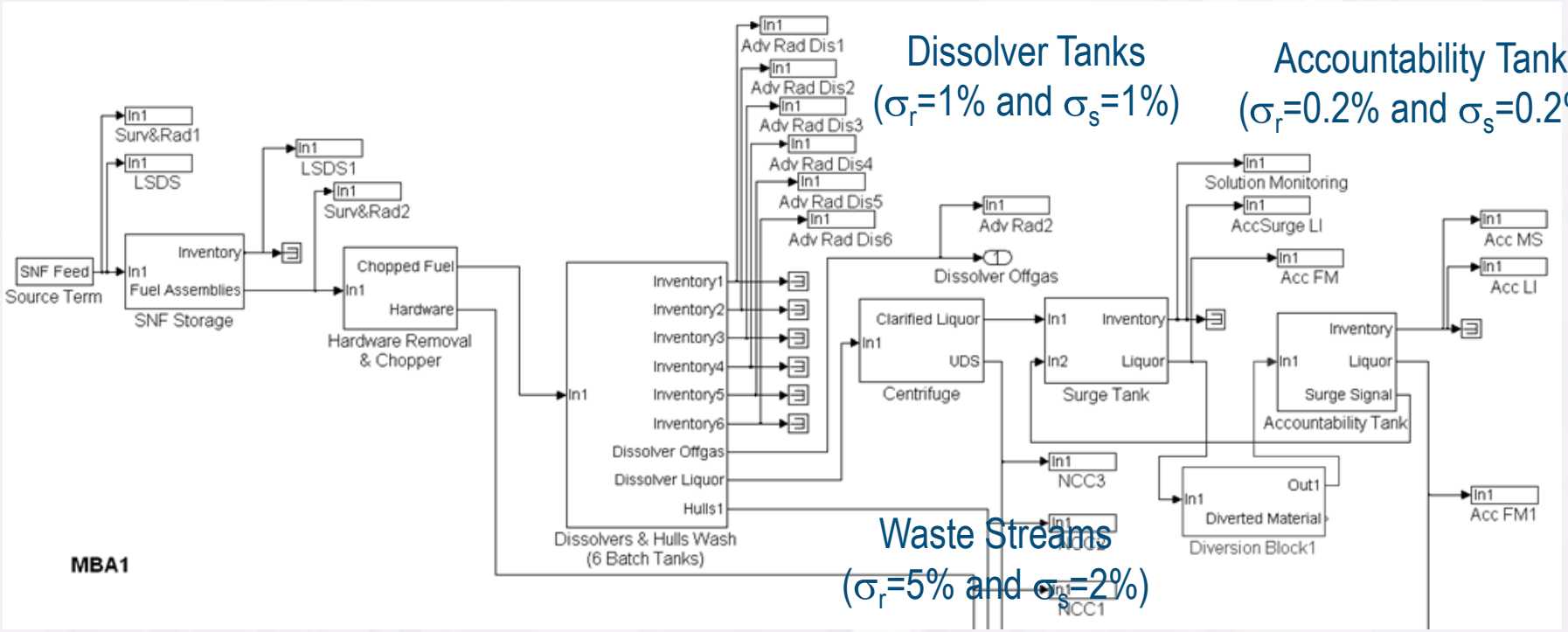


Neutron Slowing-Down Spectroscopy

- Used for decades in cross-section measurements
- Probes unique resonance structure of fissile (and absorbing) isotopes



Near Real Time Accounting (NRTA) Modeling and Simulation in MBA1 (Head End)



SNF Measurement
(σ_r=1% and σ_s=1%)

NE's R&D Does NOT focus on

- Remote Monitoring
- State-specific Safeguards Implementation
- International Safeguards agreements (CSA,AP)
- Treaty Verification & Arms Control

FC-3 Workscope Description

New technologies and approaches accounting and safeguarding of nuclear materials will be pursued under this research area. This research topic will also pursue key nuclear data and measurement techniques that could improve material accountancy. Specific university research needs for this activity include:

- **Advanced Instrumentation**

New and improved detector systems and sensor materials that can be used to increase the accuracy, reliability, and efficiency of nuclear materials quantification and tracking from the perspective of the operator or state-level regulator. This may include neutron coincidence/anti-coincidence counting, spectroscopic analysis, chemical, calorimetric, or other non-nuclear methods, as well as any other novel methods with potential MC&A benefits.

- **Advanced Concepts and Integration**

Methods for data integration and analysis, include cutting-edge work in multi-variant statistical techniques for process monitoring, risk assessment, plant-wide modeling & simulation directed at the accounting challenges of high-interest fuel cycle processes, including advanced separations processes and used fuel storage. In general, such approaches should help move MC&A from a reactive to a preventative approach

FC-3 Workscope Description (Continued)

- **Safeguards and Security by Design**

Intrinsic design features of processes, facilities, and fuel cycles systems that could increase the security and safeguardability of nuclear energy systems

- **Nuclear Data Measurements and Technology for MC&A**

High-fidelity nuclear data measurements and technology that benefit MC&A effectiveness. Such proposals should include clear sensitivity analyses addressing the benefits of the evaluation of key nuclear parameters such as multiplicity, covariance data, and cross section refinement for isotopes of interest to the nuclear fuel cycle.

Questions